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Comparative study of MIG welding and TIG welding techniques – A Literature Review

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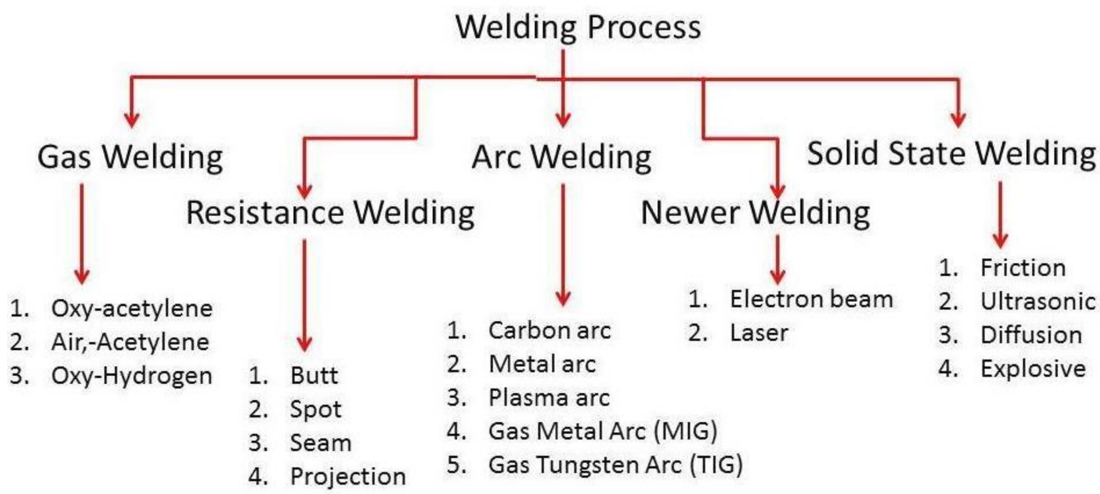
Abstract

In the present paper, we have tried to review the literature available on comparison of different welding processes and optimization methods. Comparison between different fusion welding techniques, mainly Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG) is done. The welding process can be compared in terms of microstructure, macrostructure, residual stress, mechanical properties, hardness, elongation, corrosion resistance, filler material etc. Conventional fusion welding techniques also have various problems associated with them like slow cooling rate, arc destabilization, high heat inputs etc. Further advancements in welding research has made concept of hybrid welding a possibility which is gaining popularity. The aim of the paper is to review the study done between different fusion welding techniques and compare them to provide basis for further research.

1. Introduction

Welding is a fabrication process that joins materials, usually metals by using high heat to melt the parts together and allowing them to cool, causing fusion. It is a fast inexpensive way to join two metals permanently.

There are different types of welding available, but to main classification can be done to two types i.e. Fusion welding and Solid state welding. In Fusion welding the metal is brought to its melting point and then the joining happens when metal cools down to harden and a joint is formed. Whereas in Solid state welding the metal is not melted but is joined due to pressure application and metal is in plastic state, heat is not directly applied this type of welding is also called pressure welding.



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Arc Welding: Arc welding is a type of fusion welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. Two major types of arc welding are MIG and TIG welding.

Tungsten Inert Gas (TIG): Tungsten inert gas welding (TIG) is a welding process in which the work pieces are joined by the heat obtained from an electric arc struck between a non-consumable tungsten electrode and the work pieces. The tungsten electrode is normally contacted with a water cooled copper tube, which is connected to the welding cable to prevent overheating. The shielding gas (Ar, He) goes through the torch body and nozzle toward the weld pool to protect it from air. Filler metal (for joining of thicker materials) can be fed manually or automatically to the arc. TIG welding is mainly used for thin and non-ferrous material like aluminum, copper, nickel, lead etc. The area is very small between the arc and metal being welded so it needs precision and skill for proper welding and is hard to do. Welds produced from this method are extremely strong. TIG welding produces better welds than MIG welding as it creates narrow and focused arc that penetrates better into the metal and create more heat thus it also has overheating issue.

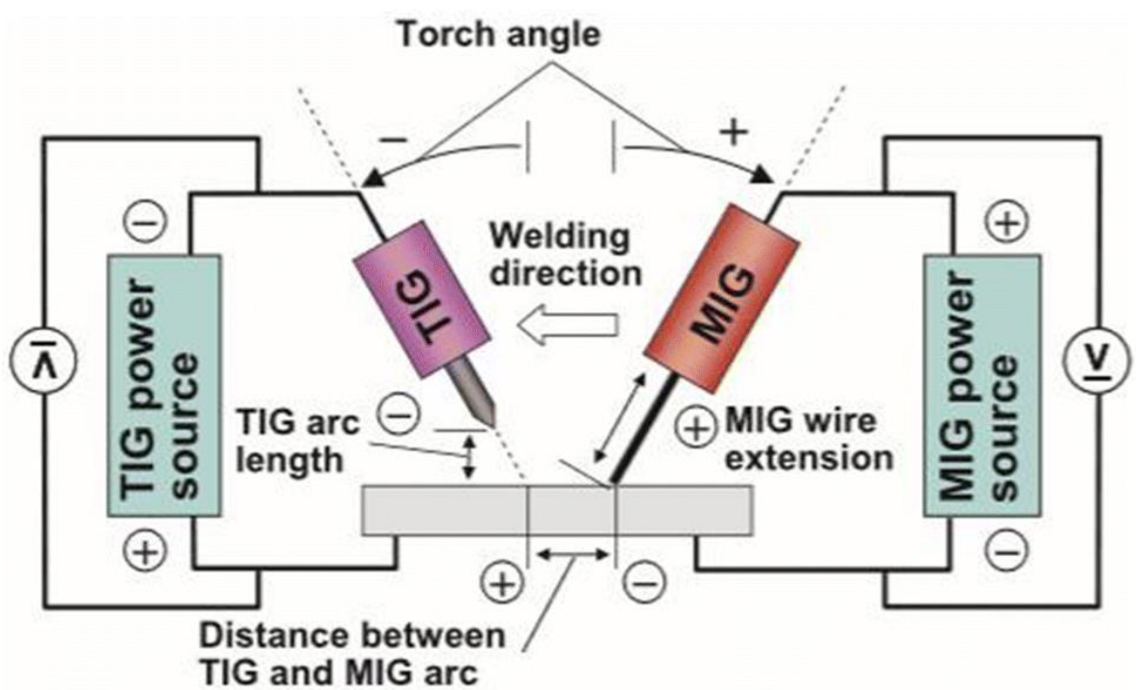
Metal Inert Gas (MIG): Metal Inert Gas (MIG) welding is a welding process in which the workpiece are joined by the heat obtained from an electric arc struck between a bare (uncoated) consumable electrode and the workpiece in the presence of an inert gas atmosphere. The shielding gas is used to protect the weld from contamination from the air, it usually contains carbon dioxide, oxygen, argon or helium. The consumable electrodes commonly used are carbon steel, stainless steel, and aluminum they are fed using feed motor. MIG welding is relatively easier to do than TIG welding as it is more flexible than TIG welding. It also doesn't have an overheating issue like TIG welding. Disadvantage of MIG welding is the arc stability issue and big arcs, thus welding smaller pieces are not advised as poor welds will be made.

2. BACKGOUND

MIG welding is incredible because of high penetration and high speed of producing welds but it has its disadvantages like less stabilized arc, smoking and fumes etc. TIG welding penetration is very less compared to MIG welding causing more production time also its electric arc can be influenced by electromagnetic field to make irregular arc. Thicker plates need multiple passes. TIG may produce high heat inputs on base metal which can result to low hardness and tensile strength. As both processes have their advantages and disadvantages various studies were done for in-depth comparison between the two.

Hybrid-welding (TIG-MIG)

Due to these shortcomings hybrid welding techniques were developed which combined two or more welding techniques one such process is TIG-MIG welding where both arcs are used simultaneously where TIG arc is leading followed by MIG arc. It improves weld quality further as it combines high-quality and high efficiency attributes of both and deposits more heat and further increase speed and efficiency. The TIG arc also helps stabilizing MIG arc which helps in clean weld formation.



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2.1 Literature Review

E. O. Ogundimu *et al (*2019) conducted an experiment to study TIG and MIG welding in which type-304 austenite stainless steel plate material of dimension of 175 mm × 100 mm × 6 mm was used for the welding operation. Three different currents of 150 A, 170 A, 190 A were used for MIG and TIG operation. Pure argon gas was used for shielding. The experiment concluded that weld shape was thin and smooth with weld width of 4mm. TIG sample contained about 66%-71%wt iron (Fe) while MIG sample had 63%-69%. The highest ultimate tensile strength (UTS) and yield strength was shown by TIG at the current of 150 A with UTS 621 MPa and 400 MPa. Surface finish of TIG was also better than MIG and at same current TIG has higher UTS, but MIG penetration was more. [1]

M. Ericsson et. al. (2003) studied the effect of welding speed on fatigue strength of FSW welds and compared it with that of TIG and MIG welds. The process used to analyze the experiment proceeded with series of fatigue tests carried out on a hydraulic testing machine. Al-Mg-Si 6082 alloy was used as the base material. The parameters used for the experiment were welding speed (mm/min) and depth of penetration (mm) in different types of joints. The experiment concluded the TIG welds had better fatigue performance than the MIG pulse welds. The fatigue strength of FSW welds is greater than TIG and MIG welds of same material at lower weld speed. [2]

G. R. C. Pradeep et al. (2013) compared the three welding processes i.e. TIG welding, Gas and Arc welding processes by studying the hard facing of AISI 1020 steel. Hardfacing is a welding techniques used to improve service life of machine parts. To study the nature of wear surface of weldments, SEM was used. The experiment concluded that TIG welding was showing better wear properties at low sliding velocity but at high sliding velocity Gas and Arc welding were superior. [3]

Radha Raman Mishra et al. (2014) compared strength of tensile strength of TIG and MIG welds of dissimilar joints of mild steel and stainless steel. The materials used were in cylindrical rod shape of length 115 mm and diameter 15 mm. The experiment concluded that length of welded zone is better in MIG weld than TIG weld, however considering tensile property TIG weld is more preferable as it has better strength also it has more corrosion resistivity, ductility and strength. The main flaw of MIG weld in dissimilar joining is the formation of cracks during welding. [4]

Cynthia Samuel Abima et al. (2022) studied combined effect of TIG-MIG (hybrid welding) arc on metal joining and in achieving improved mechanical properties than TIG or MIG welding. The material used was a mild steel plate of 6 mm thickness and a 400 DC. A butt joint was made. The experiment concluded the tensile strength of TIG-MIG was highest followed by MIG and then TIG, TIG welding also showed more percentage elongation. TIG-MIG welding showed more ductile nature. This hybrid welding also shows more efficiency than the other two. [5]

Shuhei Kanemaru et al. (2013) studied hybrid TIG-MIG welding for solving spatter problem, arc instability problem with MIG welds and improve its strength and also reduce weld time of TIG welding by 17-44%. The material used was stainless steel with current 350 A (TIG) and 270 A (MIG) with weld speed 30 cm/min and later some variations were done. The experiment concluded TIG-MIG welding stabilized MIG arc and no spatter or irregular behavior was observed and both arcs performed well. TIG current needs to be higher than MIG current for stabilization when using pure argon. Good butt joint was formed with no defects and welding time was also reduced up to 44%. [6]

Zheng Ye et al. (2017) studied effective joining between aluminum and steel using combined effects of MIG and TIG arcs with its effect on weld appearance and interface properties, as it one of the main interest in manufacturing industry. Material used were 5052 aluminum alloy and Q235 mild steel with dimensions 60 mm x 200 mm x 3 mm, with an DC MIG welding machine and AC TIG machine, butt joint was made with TIG and MIG welding torches placed on top and bottom of weld. They concluded form efficiency quantitatively reflected weld appearance which was sensitive TIG current but adapted to high welding speed. Optimum parameters were MIG voltage = 13 V, TIG current = 70 A, ration of input MIG/TIG = 1.35 welding speed = 2 cm/s. [7]

Kazi Sabiruddin et al. (2009) studied GMAW and tried controlling process parameters to obtain desired results, the optimization was done through analytical hierarchy process (AHP). The AHP is a simple and widely used decision making tool and it gives results close to experimental values. The hierarchy is first constructed with the goal at the top level of the hierarchy, in the next level subsequent sub-criteria and decision comes then the weight matrix is designed. In this experiment low carbon steel was used as the material and parameters being optimized were welding speed, welding current and voltage with selection criteria being no spatter, good penetration, no blow holes, no surface crack etc. The study concluded that for low carbon steel at 25 volt, 150 A, 370 mm/min welding speed the results were satisfactory. [8]

Abdullah Al-Faruk et al. (2010) studied metal inert gas (MIG) welding and its process parameters like arc length, arc spread, current, voltage, and controlling of these parameters to get a good weld and product quality. AHP method was used for optimization and decision making. For the experiment low carbon steel, CO_2

shielding gas and varying current form 120 A to 362 A was used. They found out that for low carbon steel parameters at 80 volts, current 316 A, welding speed 420 mm/min is best according to AHP and was confirmed with results from the experiments. [9]

Javed Kazi et al., (2015) studied MIG welding and TIG welding techniques based on hardness of welds and tensile testing carried on UTM. A standard specimen of stainless steel type of 304 was used and welded under varying conditions of voltage, current and speed. The study concluded that MIG welds have higher hardness than TIG welds in Brinell's hardness test. 185 BHN for TIG welds and 349 BHN for MIG welds, but in terms of ultimate tensile strength and yield stress TIG welding was better. [10]

Dr. S V Anil Kumar et al., (2020) studied effects of different process parameters in MIG welding like welding current, voltage, speed, gas flow rate and pressure on weld's tensile strength and percent elongation of AISI 1018 mild/low carbon steel and optimization of these parameters using Taguchi Technique for maximum tensile strength. The study concluded that increase in welding current, voltage, gas flow rate decreased tensile strength, but when welding speed increased the tensile strength also increased. [11]

Ajay Kumar et al., (2016) studied welding of aluminum alloys using TIG welding, MIG welding and Friction stir welding (FSW) as welding of aluminum alloys id difficult to high reactivity, conductivity, reflectivity and thermal expansion. FSW joints showed better mechanical and metallurgical properties than TIG welds and MIG welds. [12]

3. CONCLUSIONS

1) TIG welding and MIG welding both have their own strengths and weaknesses but strength and weld quality wise TIG welding seems to be superior in most cases.
2) MIG welds have better hardness than TIG welds
3) MIG welding has arc stability issue and TIG has overheating issue to overcome these and many more shortcoming hybrid-welding TIG-MIG is gaining more popularity as it seems to be superior in strength, weld quality, efficiency and time taken though its percentage elongation is more.
4) AHP is a powerful tool for multi-criteria decision making and for low carbon steel MIG arc is most optimized at 80 Volts, 316 Amperes, and 420 mm/min welding speed.

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